Liikennevirasto
Finnish Transport Agency

2 · 2013
PROJECTS OF THE
FINNISH TRANSPORT AGENCY

The Transport Needs of the Mining Industry

WORKING GROUP SUMMARY

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Helsinki 2013

Cover photo: LKAB, Northland Resources, Finnish Transport Agency's photo archives

Online publication pdf (www.liikennevirasto.fi)
ISSN-L 1798-8217
ISSN 1798-8225
ISBN 978-952-255-269-3

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Foreword

The Finnish mineral strategy (vision 2050) was created commissioned by the Ministerial working group on energy and climate policy. According to it, Finland is a global forerunner in sustainable use of minerals, and the mineral industry is one of the pillars of our national economy. In addition to EU actions, national measures are also needed to ensure mineral production and the development of the industry. The government program takes a positive stand to promote the mining industry as part of the foundation of our well-being.

The production of metallic mineral is estimated to multiply in Finland by the end of the decade. The growth has a significant impact on transport volumes and it requires information about the development needs of the transport system. The Ministry of Transport and Communications assigned the Finnish Transport Agency a task to clarify what are the views of companies and authorities on the transport needs of the mining industry in Northern Finland, and on functioning transport routes in both short and long term, also considering the transport and travel needs of other businesses. Furthermore, there was a task to look into the ability of the government and companies to participate in the maintenance of the transport routes and funding of their construction. The Finnish Transport Agency founded a working group for the task in the beginning of 2012, with members:

- Mervi Karhula, Chair, Finnish Transport Agency
- Markku Pyy, Secretary General, Finnish Transport Agency
- Kari Ruohonen, Finnish Transport Agency
- Riikka Aaltonen (Pekka Suomela until 31 March 2012), Ministry of Employment and the Economy
- Tuomo Suvanto, Ministry of Transport and Communications
- Petteri Katajisto, Ministry of the Environment
- Jorma Leskinen, Centre for Economic Development, Transport and the Environment, Lapland
- Timo Jokelainen, Centre for Economic Development, Transport and the Environment, Lapland
- Timo Mäkikyrö, Centre for Economic Development, Transport and the Environment, North Ostrobothnia
- Jussi Rämet (Eija Salmi until 31 March 2012), Council of Oulu Region
- Maija Uusisuo, Regional Council of Lapland
- Riitta Lönnström, Regional Council of Lapland
- Hannu Heikkinen, Joint authority of Kainuu Region
- Markku Mäkitalo, Joint authority of Tunturi-Lappi
- Kari Väyrynen/Erkki Parkkinen, Joint authority of Eastern Lapland
- Timo Lohi, Region of Northern Lapland
- Jussi Huttunen, Regional Council of North Savo
- Timo Rautajoki, Lapland Chamber of Commerce
- Jukka Mikkonen, Koillismaa

The Finnish Transport Agency assigned a steering group for the working group, with members:

- Juhani Tervala (Antti Vehviläinen as of 1 January 2013), Chair, Finnish Transport Agency
- Mervi Karhula, Secretary, Finnish Transport Agency
- Markku Pyy, Finnish Transport Agency
- Riikka Aaltonen (Pekka Suomela until 31 March 2012), Ministry of Employment and the Economy
- Tuomo Suvanto, Ministry of Transport and Communications
- Esko Lotvonen, (Regional Council of Lapland until 31 August 2012), City of Rovaniemi
- Jorma Leskinen (Jaakko Ylinampa as of 1 September 2012), Centre for Economic Development, Transport and the Environment, Lapland

The Finnish Transport Agency ordered a consultant to support the working group in making clarifications related to the domain and to provide secretarial services. Ramboll Finland Oy served as the main consultant, and the work was carried out by Marko Mäenpää, Tuomo Pöyskö, Pekka Iikkanen, Markku Salo and Antti Meriläinen. A sub-consultant in finance related issues was Juha Tervonen (JT-Con). Furthermore, the Finnish Transport Agency ordered a report from Storvik Consult on the transport needs of the heavy industry in the Barents region.

An extensive background report was drawn of the work of the working group. It presents the work and its results in more detail. This report is a summary of the extensive background report, and it presents the focal results of the working group in a concise format. The summary report has been translated from Finnish into English, Swedish and Russian.

Helsinki, March 2013

Finnish Transportation Agency
Transportation and Traffic Planning Division

Contents

1 Introduction

1.1 Starting points of the work

Economic well-being is dependent on the availability of mineral raw materials. Europe is largely self-sufficient in the production of industrial minerals and aggregate. However, in the production of metals EU is widely dependent on exported global raw materials.

Global changes in the mineral industry are an opportunity for Finland. In the Finnish bedrock, there are significant reserves of several metals and minerals, or considerable potential. It has been estimated that in the Finnish bedrock, there are minerals worth about 300 billion euros. Finland also possesses internationally valued competence and equipment manufacturing for the mineral industry. Today, there are 52 working mines or quarries, out of which 11 are metal ore mines. Mining companies are very interested in Finland, and new mines have been opened here in recent years. The volume of metal ore mining is estimated to double by the end of the decade, the focal point being heavily in the Northern and Eastern Finland. Mining industry impacts the regional economy, e.g. through increasing earned income, corporate taxes, municipal taxes and taxes related to increasing consumption. The mining industry diversifies the local business structure and as a controlled activity, also has positive impact by means of improving services and transport connections. On the other hand, mining industry has its challenges, e.g. for environmental reasons, and transporting raw materials quarried in an outlying district to the market for further processing require investments in the infrastructure.

Functioning transport connections play a key role when starting mining operations and considering continuity. Plenty of preliminary studies have been carried out in Northern Finland of transport connections and development corridors regarded as important for different lines of business. Transport system plans were completed in the districts of Lapland, Northern Ostrobothnia, Kainuu and Central Ostrobothnia last year. They studied, for example, the needs and expectations of mining and other industries (e.g. forest and metal industry and travel) for a transport system. Corresponding studies have been completed in Northern Norway, Northern Sweden and Russia. The content of the reports is heterogeneous and serve the aims of the commissioners of the studies. Now there was a need to find the overall view of the transport system of the entire Nordic region and its development needs, taking into account the opportunities to use the Arctic Ocean connections and Barents region transport connections.

1.2 Goals of the work

The aim of the work was to clarify short and long term transport needs and routes of mining industry in Finland and in the neighbouring countries. Several investment and transport solutions related to mining are taking place in the neighbouring countries of Finland, and they affect the internal transport routes of Finland. Therefore, the tasks are, for example

1. evaluate the capability and challenges of the existing transport network to meet the transport demand now and in the future

2. clarify the land use reservation needs of the new routes and their initial impact at the accuracy required by the provincial plan
3. formulate a joint national view of the transport routes offered to mining industry, in particular, and their service level up north.

In addition, there was a task to clarify the principles and funding models, which the government and mining companies could use to combine resources for the construction and maintenance of the routes needed by the mining industry.

1.3 Flow of the clarification process

The government term 2011–2015 program states that the government will strengthen the value chain of domestic mining industry and support the expedition of mining projects. In the government program, the development of infrastructure which serves the business, and therefore also the mining industry, is allocated to be handled in the Transport Policy Report.

At the end of 2011, the Minister of Transport and Communications asked the Finnish Transport Agency to study the transport needs of the mining industry in the North. The Finnish Transport Agency established a working and steering group for the purpose and ordered a consultation project, which was completed at the end of 2012.

The task focused first in the reports related to mining transport in Sweden, Norway and Russia, and in numerous reports concerning domestic mining. Hearing of the most significant mining companies as official work of the Finnish Transport Agency was part of the task. In addition, a survey was carried out about the transport needs of the major mining companies, and different players involved in the mining industry and transport were heard. In this phase of the work, tin May 2012, the Finnish Transport Agency organised a national hearing in Rovaniemi, with almost a hundred participants from different areas of the mining industry.

When clarifying the mining transport volumes and routes, an international seminar was also organised in Rovaniemi in September 2012. That is where the neighbouring countries' latest outlooks, transport needs and utilisation goals of the Arctic were heard. The work to find a common vision for a joint transport system of the entire northern area was also began in the seminar. About 80 people participated in the seminar; one third of them represented the neighbouring countries.

The background report created by the working group was sent to an extensive stakeholder group for commenting in late 2012. Based on the feedback received, the modified report was presented in the final seminar of the project on 27 February 2013; the seminar was aimed at mining industry decision-makers and all those involved in mining. The report was finalised based on the feedback received in the seminar. This summary is created from the extensive background report for the use of the working group.

The transport needs of the mining industry and other industries, factors affecting the demand for transport and selection of transport, transport route options and financial comparisons of them and funding options are described in detailed in the background report of the working group. The report also presents the neighbouring countries' transport needs and transport routes with border crossing points.

1.4 Feedback received during the work

Feedback and viewpoints were received from different stakeholders in the seminars, hearings, interviews, surveys and other meetings organised by the project's working group. In addition, the background report of the project was sent for commenting to about 300 interest groups. The feedback received was used in the work whenever possible.

The feedback received during the work was mostly positive and the work was regarded as realistic, comprehensive and thorough. The background report of the project was seen to serve well the needs of the near future, in particular. However, some interest groups wanted bolder long-term visions.

The work focused on mining industry transport, but it also covered some of the transport needs of other industries. Part of those providing feedback would have wanted even deeper analysis and visioning of the transport potential and impact of other industries (including travel), as well as the impact and opportunities of the changes in the Barents area operational environment. Some people providing feedback would have liked to see a more detailed analysis related to the impact of the sulphur directive. The foreign ownership in the mining industry raised a lot of concern in the different hearings. Mostly people hoped that products would be refined as far as possible in Finland. In addition, the dependency of Finland and EU of the export of metals and minerals was noted. New mining projects in Finland would increase self-sufficiency.

2 Current transport volumes and routes of the mining industry

2.1 Current transport volumes

The aggregate transport volumes of the metallic mineral mines in the planning area amounted to about 2.5 million tons in 2011. The share of the Kemi (Outokumpu Chrome), Pyhäsalmi (Inmet Mining Corporation) and Sotkamo (Talvivaara Mining Company Plc) mining transport was almost 90 per cent. Proportioned with other transport volumes, the transport volumes of the planning area's metallic mineral mines correspond to about five per cent of the aggregate road transport of the northern regions and less than ten per cent of the aggregate railway transport of all of Finland. To compare, it is worth mentioning that the LKAB transport volumes alone in Norrbotten in Northern Sweden total almost 30 million tons per year. Even though the transport volumes of Finnish mines are relatively small compared to overall transport volumes, their impact on individual road and rail connections is considerable.

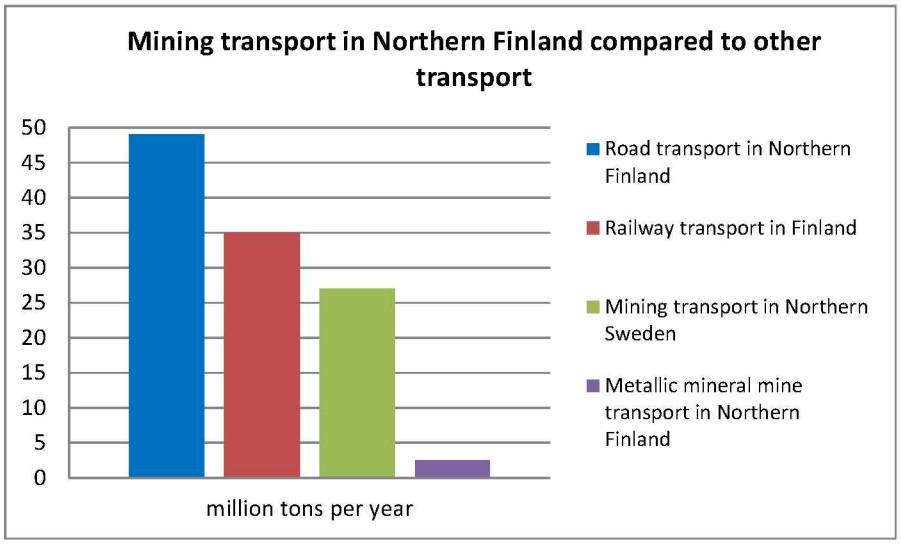

Figure 1. *The transport volumes of the mining industry in Northern Finland compared to all road transport in Finland, Finnish railway transport and mining industry transport in Northern Sweden.*

The most significant **main roads** of the planning area are the highways running from north to south 4, 5, 6, 8 and 21 and westbound highways 13, 17, 20, 22, 27 and 28. The most significant international connections in the planning area are the Europe roads, of which E4 heads toward Southern Sweden from the border of Finland, E6 from Northern Norway towards Southern Norway, E8 from Western Lapland to Northern Norway, E10 from Northern Sweden to Narvik, E63 from Eastern Finland and E75 from Western Finland via Lapland to Northern Norway and E105 from Northern Norway via Murmansk to St. Petersburg. The main road network is mostly in good condition and there are no significant bottle necks. As the traffic and transport volumes increase, in particular on highway 4 between Oulu–Kemi, there is a need to increase the capacity. Regarding the functioning of the transport of the current mines in Northern and Eastern Finland, deficiencies occur mainly in individual spots, most of them are located in the lower road network.

The **railway network** consists of the main line from Kokkola to Kolari and Kelloselkä, and the Savonrata line from Kuopio via Kontiomäki to Oulu and Vartius. The Iisalmi–Ylivieska line is also an important part of the freight traffic route. A large part of Lapland has no railway network. The lines of the area are monorail and the highest permitted axle load is 22.5 ton. The lines are electrified on the main line up to Laurila and Rovaniemi, on the Savonrata line up to Oulu and Vartius. From the railway network of Northern Finland there is a connection to the Russian railway network via Vartius, and to the Swedish railway network via Tornio.

In the Nothern Finland railway network, the most significant lacks of capacity occur in the section Kokkola–Ylivieska. Between Ylivieska–Iisalmi and Kontiomäki–Oulu the capacity also restricts increasing the transport volume. The development of sections Kokkola–Ylivieska and Ylivieska–Iisalmi, which will eliminate the most significant lacks in capacity, is included in the investments of the government term in the Transport Policy Report. There may be capacity issues in other railway sections, as well, if the planned growth projects will realise.

In Northern Sweden on the Iron Ore Line Boden–Kiiruna–Narvik there are significant capacity deficiencies already with the current transport volumes. The different rail gauges in Finland and Sweden cause a significant bottleneck in the transport. The current capacity of the Murmansk line in Northwest Russia does not allow increases in the transport, either.

Maritime transport play and important role, especially in the transport of raw materials and products of heavy industry. In the clearing area by the Bothian Bay there are six harbours, Tornio, Kemi, Oulu, Raahe, Kalajoki and Kokkola, of which Kemi, Oulu, Raahe and Kokkola were included in this study. The depth of the sea routes of the Kemi, Oulu and Raahe harbours is about 10 metres, and that of Kokkola about 13 metres. The year-round traffic of the Bothnian Bay harbours requires icebreaking in winter months. The traffic in the Bothnian Bay harbours is limited by the shallowness of the Northern Quark, where the deepest draught is about 14 metres. The draught of the straits of Denmark is about 15 metres. In the Barents area in the Arctic Ocean there are several harbours in Norway and Russia. Of those, Narvik and Murmansk, in particular, are specialised in the transport of different mining products. The Arctic Ocean harbours are mostly ice-free year round.

The Kokkola harbour, in particular, has free capacity and readiness to increase the current transport volume. Other harbours also have plans to improve the operations. If the planned mining project are started and transport directed to the Bothnian Bay harbours, additional investments must be made in them, related to capacity and services.

The Ministry of Transport and Communications has assigned a working group to prepare a sea transport strategy which addresses the harbour policy, among other things. The results of the working group will be ready at the end of 2013.

Air traffic offers fast passenger and freight traffic connections for the businesses and travel in the area. The most important airports of the area are Oulu, Rovaniemi, Kajaani, Kuopio, Kittilä, Ivalo, Joensuu, Kokkola-Pietarsaari and Kemi-Tornio. Fast air freight connections are used by enterprises which manufacture products of a high degree of processing, but air freight is also used for transport of metal, energy and forest industry spare parts. All airports have regular airline service for passenger

traffic to the Helsinki-Vantaa airport. Practically all airports have the capacity to increase the current transport volume.

The Ministry of Transport and Communications is preparing an air traffic strategy which also covers the airport network. The air traffic strategy will be completed by the end of 2014.

Figure 2. *The most important ground transport connections, harbours and airports of the planning area.*

2.2 Future outlook of the volumes and trends of mining transport

In Northern Finland there are several different, strategically important traffic and transport corridors. In the proposal by the European Commission, the TEN-T core network contains the Motorways of the Sea and as a new project, the Bothnian Corridor. The above mentioned corridors play a major role in current and future mining industry transport. The "Northern Axis" traffic corridor defined by the High Level Group of the European Union connects Northern Europe to Norway on one hand, and to Belarus and Russia on the other. In addition, there are several other transport corridors in the area that connect other neighbouring countries.

Several new mines are being planned for Northern and Eastern Finland. Mining projects that have advanced far in the planning and that have significant transport volumes include Savukoski (Sokli), Kolari (Hannukainen), Ranua (Suhanko) and

Taivalkoski (Mustavaara). In addition, the extension of the Kemi mine will be competed in 2013. In Sotkamo (Talvivaara) and Sodankylä (Kevitsa) there are plans to expand the production. In the coming years the most significant impacts on transport demand can be expected at the Kolari and Sokli mines. In the long term, new transport need will emerge in the ore zone of Middle Lapland.

In a study carried out in Sweden in 2011, the mining industry of the northern region was estimated to increase considerably within the next ten years. The growth is estimated to be highest percentage-wise in the Finnish Lapland and Västerbotten in Sweden, but measured in tons, in Norrbotten in Sweden and in the Kola Peninsula in Russia. In Northern Sweden there are plans to expand the current production and open several new mines with significant transport volumes. The current annual transport volume of a little under 30 million tons is expected to grow to about 70 million tons by the end of the decade.

In Norway, the mining industry does not play such a big role as in Sweden, although there are several significant mines in operation in Northern and Central Norway. The plan is to open several new and previously closed mines in the area, and expand the production of some of the current mines. The current annual transport volume of about 8 million tons is expected to grow to about 12 million tons by the end of the decade.

Northwest Russia has long traditions in mining industry and a number of important mining projects are under planning there, as well. There are different estimates of the transport volumes, but based on a Swedish report, the transport volumes would increase to about 30-50 million tons by the end of the decade.

In addition to mining industry, today the most significant transport volumes of the planning area come from metal and forest industry transport. Russia joining WTO lowers the wood duties and, according to timber companies, increases import of wood from Russia. The impact concerns mostly the forest industry in Southeast Finland. The use of energy wood is predicted to double in Finland by 2020. The sizeable investments of the Barents area oil and gas industry increase the need from international transport up north. The demand for chemical industry products is expected to grow, especially as mining industry develops. The growth in fish transport from Northern Norway increases road transport via Finland to Russia and Eastern Europe. The tourism of the Barents area is also expected to grow considerably, which will increase the demand for air traffic, in particular, but also the demand of other forms of transport.

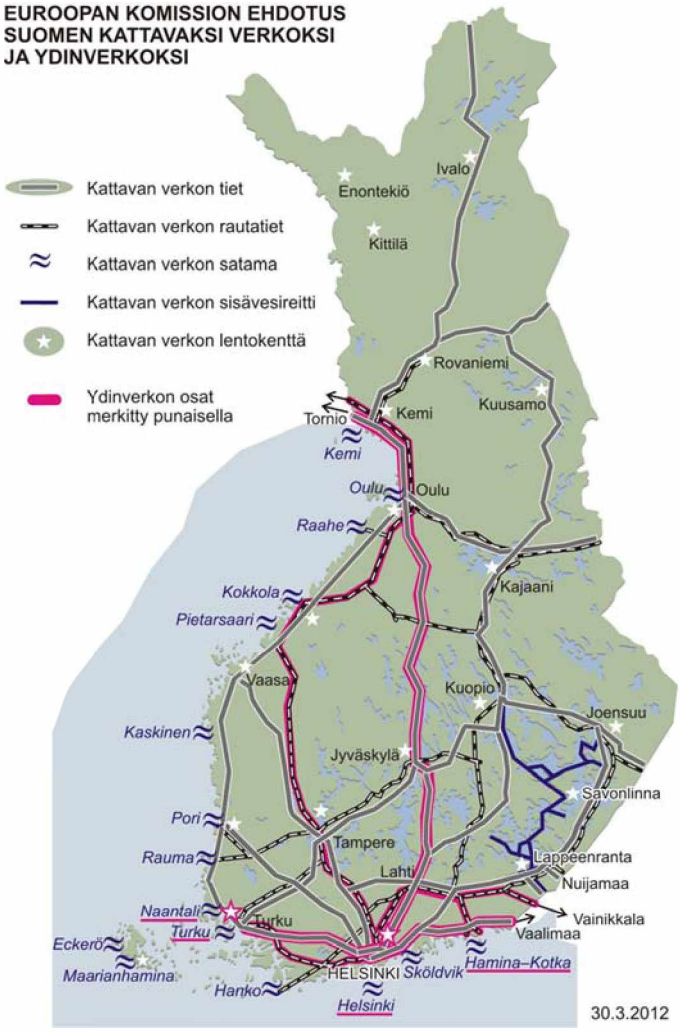

Figure 3. *The proposal of the European Commision for a network covering TEN-T and core network in Finland (www.liikennevirasto.fi).*

Scenarios for examining different transport routes were formed of the development of mining transport by regions, and the development of volumes was evaluated in a short term (year 2017) and long term (year 2030). The longer time period was studied through predictions of both moderate and major growth. The starting point of the volume scenarios was the estimates of mining companies on the development of transport volumes and inbound and outbound transport to and from the mines. The long-term estimate also takes into account the data about the volume and location of mineral resources. Furthermore, the transit transport of mining products between the Kokkola harbour and Vartius are evaluated.

If the mining projects progress as planned, mining transport is estimated to be in all about 7 million tons per year in 2017. The production will have started in most of the planned mines, or is about to start. By 2030, in the scenarios of moderate growth the assumption is that the planned mines are in full production mode. Then the transport volume may grow up to 13 million tons per year. In the scenario of major growth, the assumption is that in addition to the mines currently under planning several new mines with significant transport volumes have been opened. In the scenario of major growth, there is mining transport of almost 24 million tons per year. In addition to these, there will be transit transport, about 2.5–4 million tons per year.

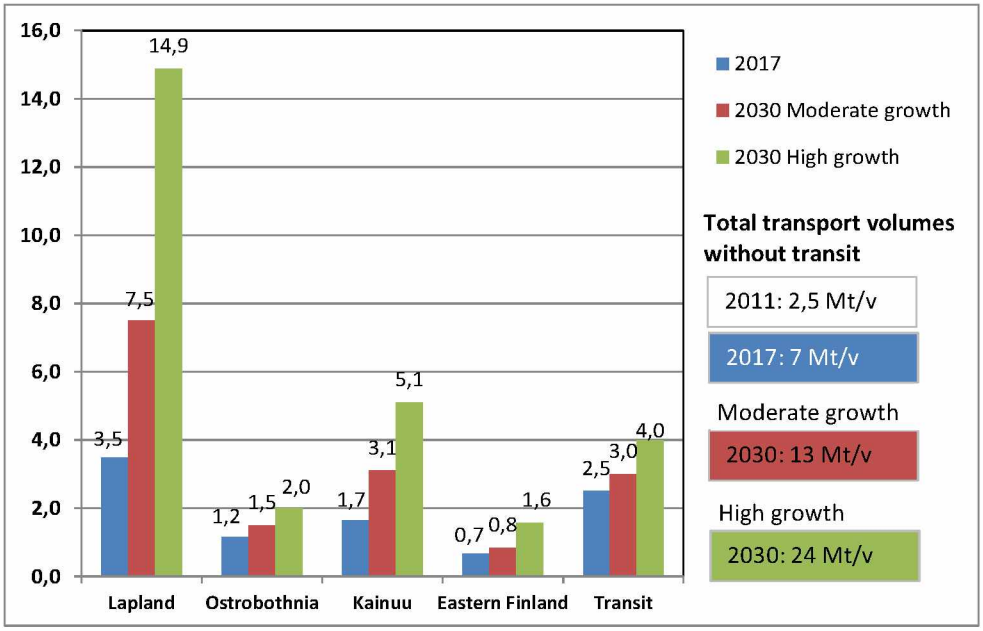

Figure 4. *Volume scenarios of mine transport (million tons/year) by region in 2017 and 2030.*

In the evaluation of the type inbound and outbound traffic at the mines, the starting point of the evaluation was the estimates of the mining companies on the place of departure and destination locations of product and raw material transport. The outlooks and available information about the orientation of the transport were for many parts quite inadequate and contained several uncertainty factors. For this reason, the orientation was evaluated with three different emphases; Finland, Europe and far-off countries. In the Finland scenario, the transport is considered to be bound to Finnish, and in Europe to European and in the far-off country scenario, to production plants of the far-off countries. The orientation scenario of the transport was used when comparing the different transport options.

2.3 Transport route options

Two main development options emerged from the report; transport via the harbours of the Bothnian Bay or Arctic Ocean (Narvik, Skibotn, Kirkenes and Murmansk). The development options were compared to each other and to the comparison option 0+. When comparing the option, it should be considered that the **investments contained in option 0+ are included in all development options to be compared**.

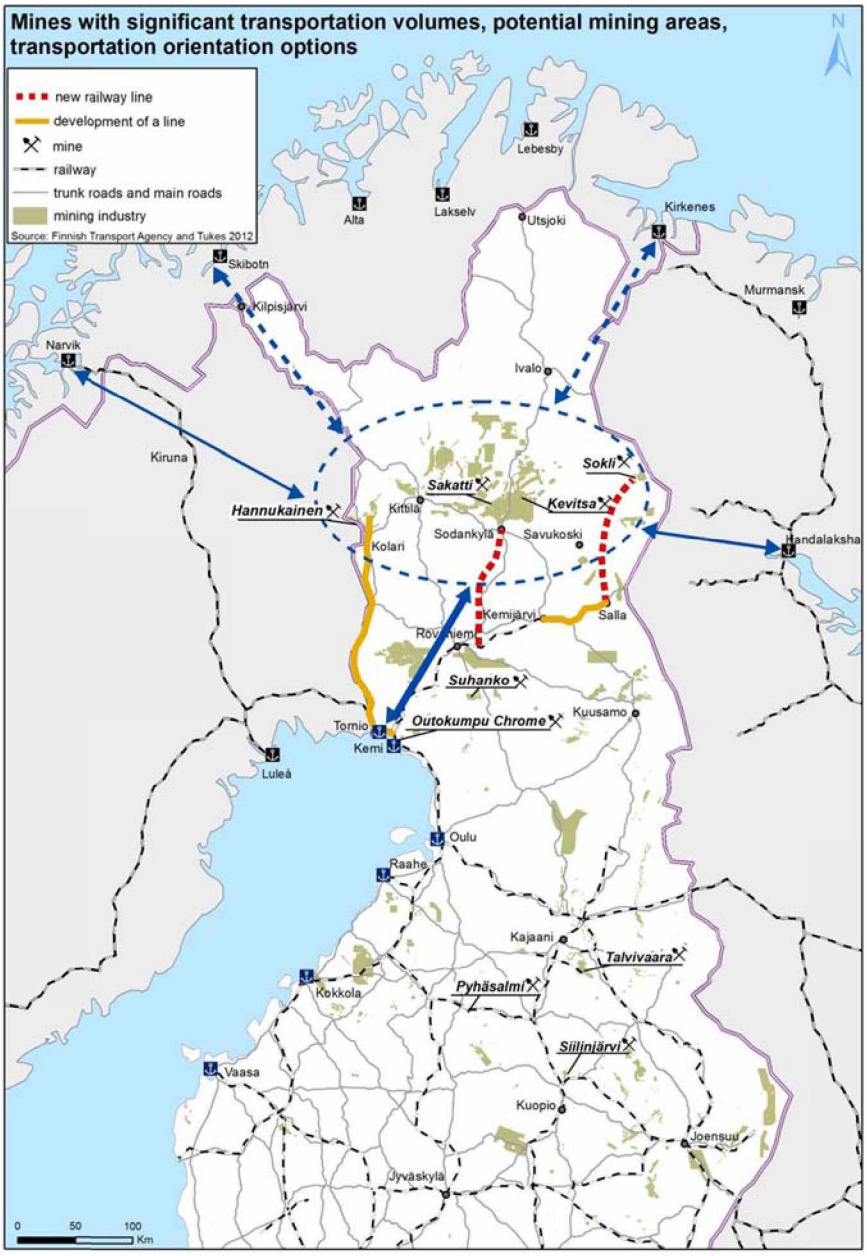

Figure 5. Orientation options of mining transport studied during the work.

Comparison option 0+ was formed of the current transport network leading to the Bothnian Bay harbours, supplemented with the new transport connections required by the Kolari and Sokli mines and other capacity investments on other parts of the railway network (Figure 6), independent of the development options. In addition, the option contains measures that improve the data connection of the current mines for the amount of about 50 million euros. The investment costs of comparison option 0+ are altogether about 610 million euros (MAKU 150). The comparison option 0+ also takes into account the development of railway connections Oulu–Vartius and Ylivieska–Oulu, the ongoing construction of the double track of Ylivieska–Kokkola and the development of the railway connection of Ylivieska–Iisalmi–Kontiomäki rail link, the implementation of which is planned to start during this government period, based on the Transport Policy Report to start this government period. The decisions concerning these projects are already based on the transport and passenger traffic needs, and their cost estimates are not included in the costs of the 0+ option.

In the Bothnian Bay development option, routes traveling through the Finnish Bothnian Bay harbours will be developed by deepening the sea routes of the harbours and docks as well as improving the current railway lines as required by transport demand, e.g. the electrification of the Kolari line (figure 6). The basic option does not include building new tracks. However, the profitability of building the Middle Lapland railway connection (Rovaniemi–Sodankylä- and Kemijärvi–Sodankylä lines) and as one entity the renovation of the Pesiökylä–Taivalkoski- line and constructing the Taivalkoski–Mustavaara line were evaluated as a separate study. The investment costs of the Bothnian Bay development option are about 760–780 million euros (without the separate study projects) (MAKU 150).

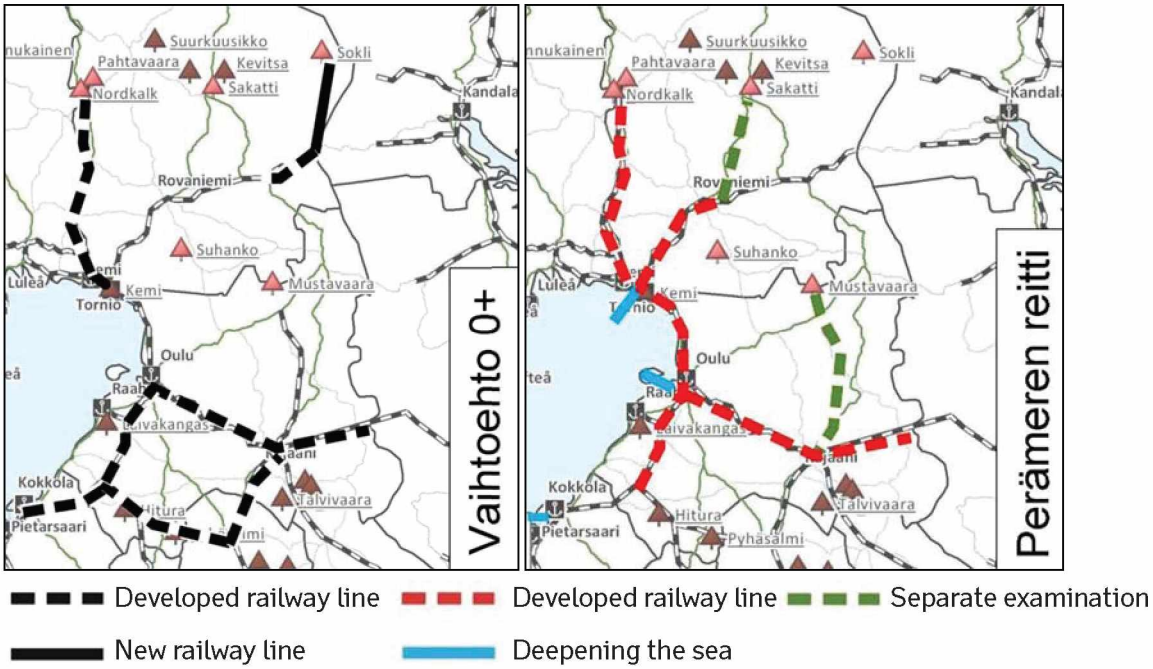

Figure 6. *Investments required by option 0+ (left picture) and Bothnian Bay route (right picture) (no investments presented separately for option 0+ in the Bothnian Bay picture).*

In the Narvik development option a new line is built with the rail gauge of Sweden from Kolari to Svappavaara via Pajala, and the line leading to Narvik via Kiiruna will be developed so that the transport can take place all the way by train (figure 7). In the sup-option, the line connection will be extended from Kolari to Sodankylä. The development of the route will require considerable investments in the Swedish and Norwegian rail networks, which are mostly connected to the increasing transport needs of the Swedish mines. The investment costs of the Narvik development option are about 700–1,130 million euro, depending of the option, of which the share of the Kolari–Kaunisvaara track is about 110–120 million euros. The cost estimate does not contain investment needs in Sweden and Norway West Kaunisvaara.

In the Skibotn development option a new line will be built with the Finnish rail gauge from Kolari to Skibotn and a new harbour to Skibotn (figure 7). In the sup-option, the line connection will be extended from Kolari to Sodankylä. The investment costs of the Skibotn development option are about 3,030–3,470 million euros (MAKU 150), depending of the option, of which the share of the track to be built from the border of Norway to Skibotn is about 646–665 million euros.

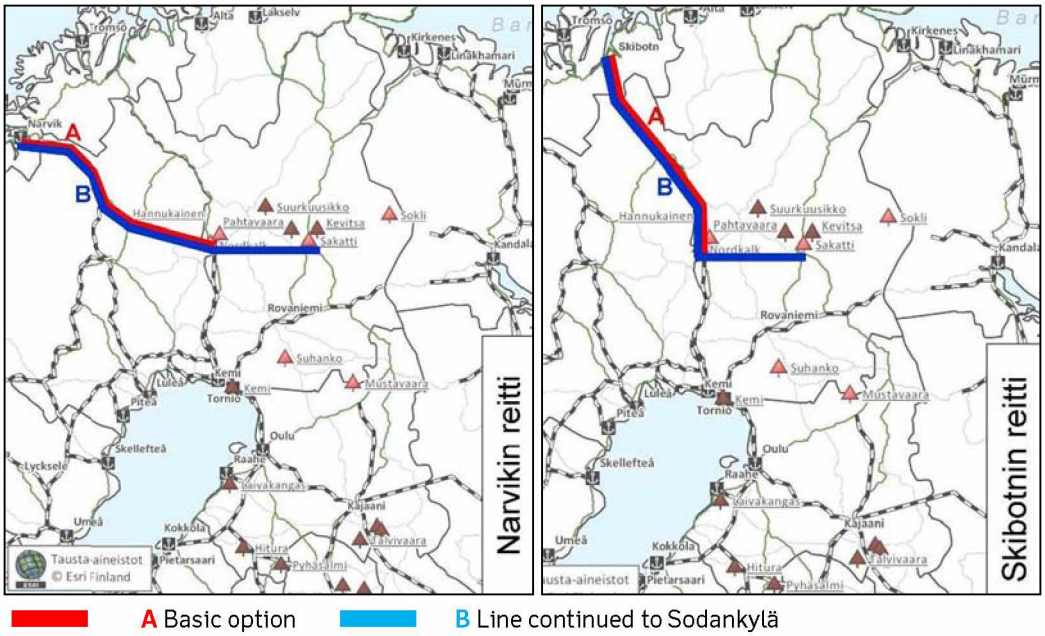

Figure 7. *Investments required by the Narvik route (left picture) and Skibotn route (right picture) (no investments presented separately for option 0+).*

In the Kirkenes development option a new line will be built with the Finnish rail gauge from the mining area in Sodankylä to Kirkenes in Norway and the harbour of Kirkenes will be developed (figure 8). In the sup-option B, the line connection will be extended from Sodankylä to Kolari. The investment costs of the Kirkenes development option are about 2,840–3,220 million euros (MAKU 150), depending on the options and railway line routing, of which the share of the track to be built from the border of Norway to Kirkenes is about 618–945 million euros.

In the Murmansk development option a new line will be built with the Russian rail gauge from Kelloselkä to Russian Alakurtti, the section between Alakurtti and Kantalahti will be improved, as well as the Murmansk line, if necessary (figure 8). In the Murmans route there are two sub-options: B extends the line connection from Sokli to Sodankylä and C from Sodankylä to Kolari. It must be noted that the development of the route will require considerable investments in the Murmansk line, which are mostly connected to the transport needs of Russia. The investment costs of the Murmansk development option are about 770–1,640 million euros, depending on the option, of which the share of the border of Russia–Alakurtti track is about 75–90 million euros. The cost estimate does not contain investment needs in the Murmansk line.

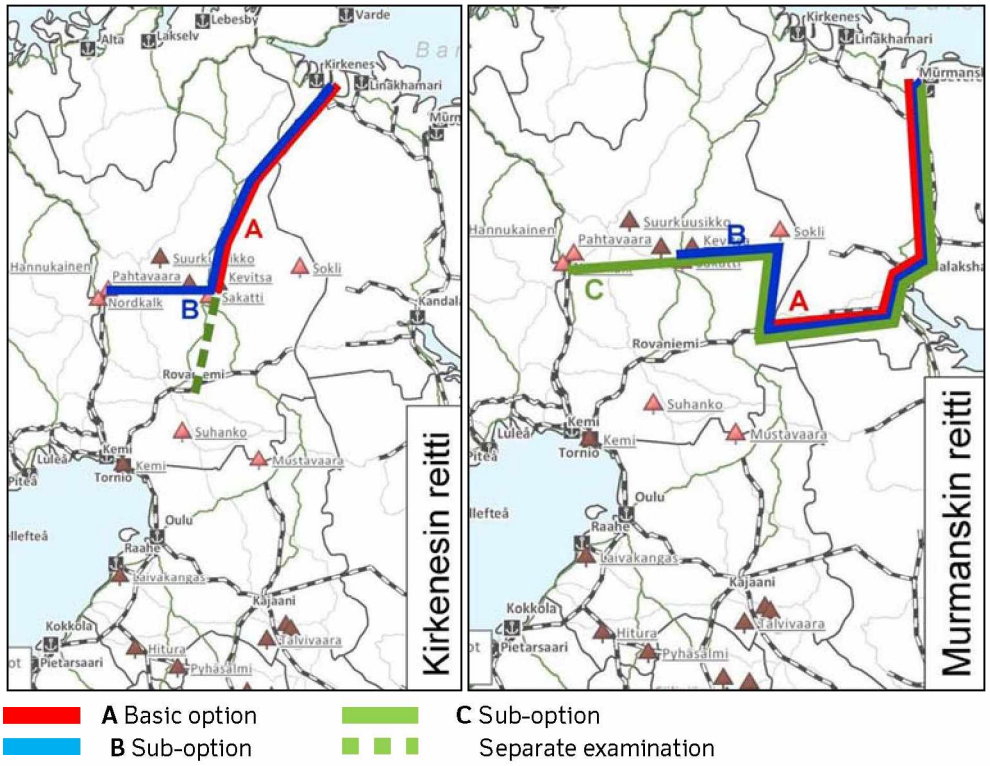

Figure 8. *Investments required by the Kirkenes route (left picture) and Murmansk rout (right picture) (no investments presented separately for option 0+).*

2.4 Comparison of options

The development options were compared to the above described 0+ option based on investment, transport and route maintenance costs. Common and uniform principles were used in calculating the costs (MAKU 150). The background report contains a comparison of all the option combinations. The following limits the processing to results that are essential for the examination.

The **investment costs** of comparison option 0+ are about MEUR 610. The investments contain, e.g. the line investments required by the Kolari and Sokli mines and measures that improved the road transport connections of the current mines. Costs of different development options (including the costs of the comparison option 0+) MEUR 760–780 (Perämeri), MEUR 700–1,130 (Narvik), MEUR 3,030–3,470 (Skibotn), MEUR 2,840–3,220 (Kirkenes) and MEUR 770–1,640 (Murmansk). The lowest cost estimate of the range represents the basic option without the development solutions of the sub-options. The above mentioned investment costs do not take into account investments from west of Kaunisvaara, because they mostly serve the transport needs of Swedish mines. Correspondingly, the costs do not contain the development costs of the Murmansk line.

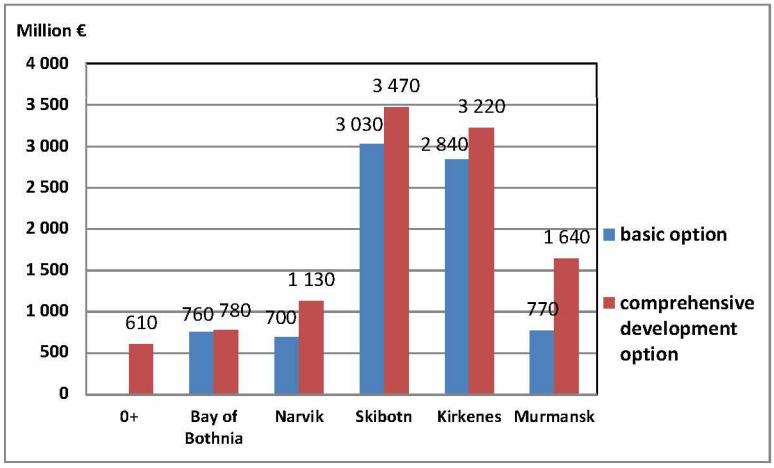

Figure 9. *Investment costs of route options million euros (MAKU 150) in the basic option (Min) and in the comprehensive development option (Max).*

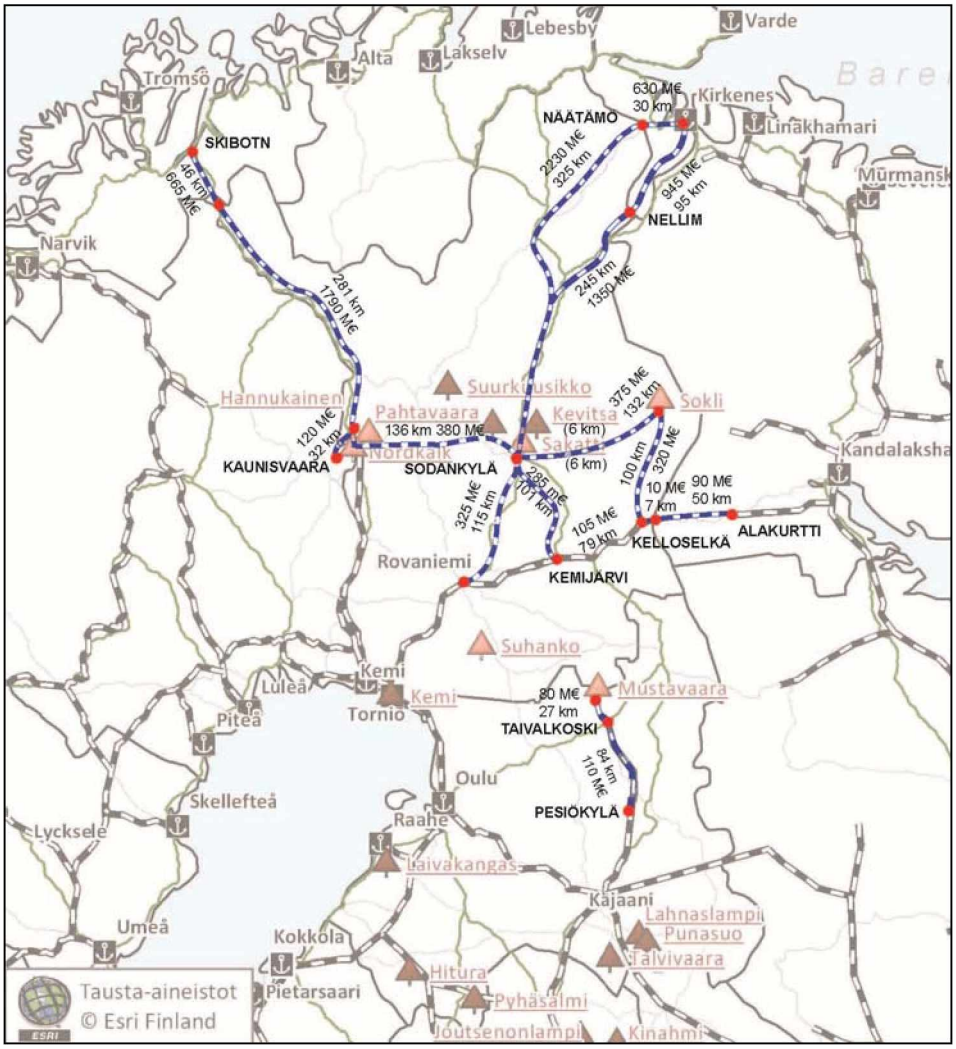

Figure 10. *Locations and cost estimates of the new lines included in the route options (MAKU 150).*

In addition to railway line investments, the development of the transport route options requires investments in the road network and sea routes. Securing the service of the current mines in Northern and Eastern Finland requires small development work of the road network with total cost of about 50 million euros. These are included in the investments of the comparison option 0+.

The transport needs and operational prerequisites of the new mines to be opened can mainly be secured by developing the current transport network. The traffic and transport of the mines in Middle and West Lapland, in particular, when realised, require widening the road and improving the road structure of highways 4 and 21, which amounts to about 50 million euros worth of investment costs in total. For the traffic to flow, it is also important to improve highway 4 between Oulu and Kemi. In addition, mine specific development investments are needed for the lower road network. The road investments for improving the service of the mines to be opened are not included in the calculations, because the related information is not comprehensive.

Based on the preliminary plans of the Finnish Transport Agency, the cost estimate of the 12-metre route of Oulu is about 13 million euros, the Kemi 12-metre route about 16 million euros and the Kokkola 14-metre route about 55 million euros (MAKU 150). The above cost estimates concern only the sea route maintained by the government. These investments are only included in the costs of the Bothnian Bay option. In addition, investments in harbours and the incoming routes maintained by the harbours will be needed. Currently the Kokkola harbour has the best readiness to manager mining transport.

Regarding the entire transport chain, **transport costs** contain the costs between the mine and the domestic place of use or procurement place of the raw material, the transport between the mine and the export/import harbours, the cost of cargo handling in the harbour, port charges and charges for the sea transport, including related fees. The costs are calculated in the production cost price. The destination defined for export transport in the calculations is Rotterdam in transport to Europe and Shanghai in transport to overseas. In the basic calculations the transport takes place via the Suez Canal, but in the separate examination the role of the North-East Passage has been considered.

In the forecast case of moderate growth, in 2030 the transport costs of the comparison option will be MEUR/y 285, 320 and 420, depending on the weighting (home country, Europe and overseas). Corresponding numbers are MEUR/y 280, 310 and 410 in the Bothnian Bay, MEUR/y 275, 300 and 375 in the Narvik, MEUR/y 270, 295 and 370 in the Skibotn, MEUR/y 280, 305 and 380 in the Kirkenes and MEUR/y 285, 315 and 400 in the Mursmansk development options. If the forecast case is major growth, the transport costs will naturally be higher than presented in the following figure, but they will not change the comparison setting.

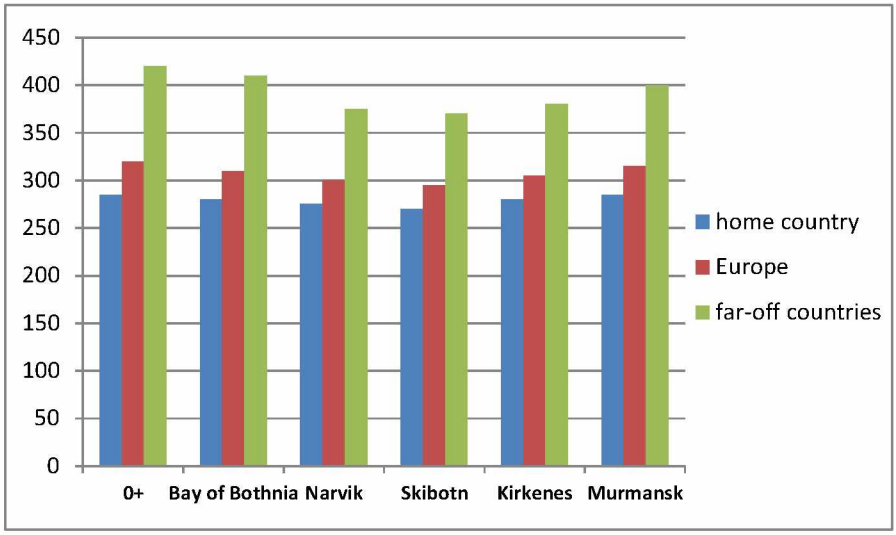

Figure 11. *The transport costs of the route options (million euros/year) in the forecast case of moderate growth in 2030 with weightings of different orientations*

The route maintenance costs will grow in all options. The impact is dependent on the length of new lines and partly on the growth of the need for icebreaking in the Bothnian Bay route. The significance of changes in route maintenance is, however, low from the overall economy, because depending on the option they form about 1–2 per cent of the transport costs.

The **present values** of total costs (incl. investment, transport and route maintenance costs) of the different transport routes provide an understanding of the cost-efficiency of the different options. The comparison shown in the following figure was made for a 30-year period according to the moderate growth Europe weighting option. The most competitive option is included in the figure from each transport route. In the forecast of major growth the total costs are one order of magnitude higher, but they do not impact the mutual comparison setting of the options. The results show that in the long run the Narvik an Murmansk options are also competitive, in addition to the Bothnian Bay option. **However, it must be noted that the investments required by the Narvik route have not been included in Sweden and Norway from west of Kaunisvaara, because the investments mainly serve the transport needs of Swedish mines. Correspondingly, the calculation does not contain the investments required for developing the Murmansk line.** The setting is largely impacted by the realisation of the transport scenarios and the development outlook of the Arctic Ocean routes.

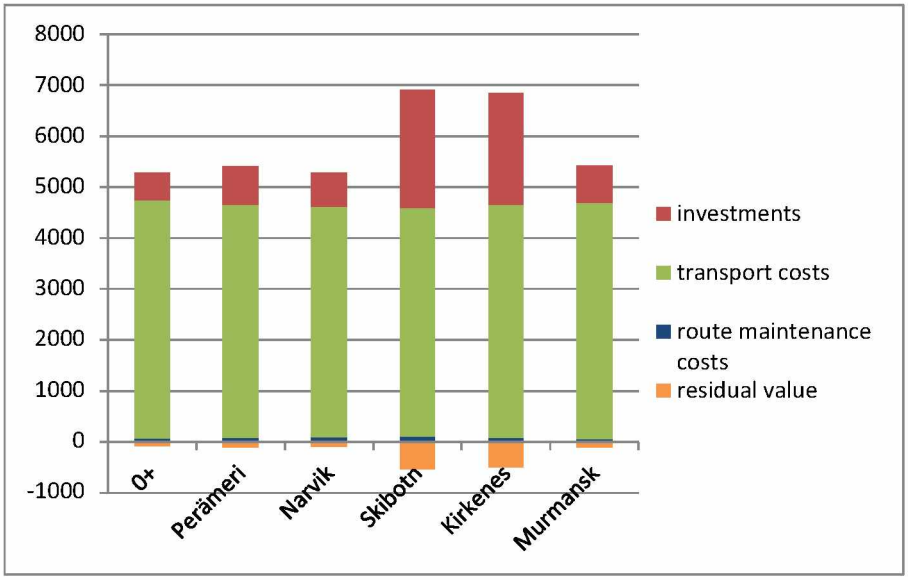

Figure 12. *The present values (million euros) of the route options' total costs for the 30-year period in the moderate growth Europe weighting case (most competitive option of each route).*

The significance and prerequisites of building the new Sodankylä line from the Kemijärvi railway section to the Sodankylä mining area and the profitability of the railway connection to the Mustavaara mine in Taivalkoski was **examined separately**. According to the clarifications the rail connection, which costs about 425 million euros, to the Middle Lapland mining area in Sodankylä would bring the biggest benefits in the Bothnian Bay route option, because the transport of the Middle Lapland mining area could be handled as direct rail transport to Bothnian Bay harbours and production plants. Due to the high investment costs of the project, the annual transport volume of about three million tons is required for the line to be profitable. The opening of the Mustavaara mine rail connection would require rail investments of about 150 million euros. Based on the calculations the benefits of the project in mining transport and raw timber transport are not high enough to make the project profitable.

2.5 Opportunities and challenges of the Arctic

The ice cover of the Arctic Sea has thinned and the size of the fast ice area has already been reducing for five decades. All climate models show that the arctic climate change and reduction of ice cover in the arctic sea areas will continue throughout the 21st century. It is fairly safe to say that the duration of free water in the North-East Passage will become longer due to the arctic climate impact.

The length of the marine transport route between the two big transport clusters, Rotterdam in Europe and Shanghai in Asia, is about 40 per cent shorter via the North-East Passage than vie the Suez Canal. The transport of the northern marine route has started to grow, but due to the short annual availability of the route and the scarcity of vessel base suitable for arctic conditions, the total volume is still modest compared to the transport via the Suez Canal or the route located south of Africa. The use of the North-East Passage may increase in case it brings savings to the users, compared to the use of the current transport routes.

Despite the opportunities provided by the North-East Passage, there are still many significant uncertainty factors and risks related to the use of the route, such as navigation in unpredictable ice and weather conditions, route depth that restricts the vessel size in the southern routes, availability of icebreaker services, traffic control, surveillance and security services, and the pricing of the route's use. The northern route will only supplement the southern route in the future, as well, the main reason being that it will continue to be available for use for only part of the year. The arctic conditions are also reflected in the building costs of the vessels and the magnitude of the route fees. Furthermore, operating in ice significantly increases the fuel consumption of vessels and thus cuts down the benefits obtained from a shorter journey.

The sulphur directive entering into force in 2015 will raise the costs of transport on the Baltic Sea, North Sea and the English Channel. This may increase the demand for transport in the harbour of the Arctic Sea, which makes it possible to avoid using the sea areas the sulphur directive concerns. The impact on transport costs may be significant, but it is impossible to predict the true magnitude of the impact in the long term. It will take years for sulphur washers to become common, but if the current technical solution proves to be functioning, the major impact of the sulphur directive on transfer costs may remain a temporary phenomenon. If the only working solution is to use low-sulphur or sulphur-free fuel, the magnitude of the increase of transport costs will be dependent on the development of the fuel market. From the point of the feasibility comparison of the development options under scrutiny, it is also essential if the requirement to use low-sulphur fuel concerns the northernmost sea areas of Europe, as well, and what the enforcement schedule would be.

The feasibility of using the North-East Passage in the Shanghai mining transport under scrutiny is dependent on the size and speed of the vessel in the North-East Passage. Based on the study, savings can be reached through using the North-East Passage in Far East mining transport and Bothnian Bay and Arctic Sea routes. The benefit of the North-East Passage in transport via Arctic Sea harbours will remain low if the speed and vessel size are smaller than in the Suez route due to ice conditions. The benefits gained from using the North-East Passage would clearly grow compared to the Bothnian Bay route, if Capesize vessels could be used in the North-East Passage. The use of vessels of this size is only possible for part of the year. Therefore, the possibility to use the North-East Passage would not change the feasibility of the transport route options examined in this work, regarding the overall economy.

In a separate study ordered by the Finnish Transport Safety Agency and the Finnish Transport Agency the operating costs of transport routes between Europe and Asia were compared with the Frisbee model. Based on the results, the North-East Passage may be competitive regarding its operating costs in raw material transport, if there is a sufficient amount of cargo.

Figure 13. Maritime routes traveling through the North-East Passage and Suez Canal.

3 Funding of the maintenance and building of transport routes

There is a principle decision on government funding by the Cabinet Committee on Economic Policy from 2008. In the future it is necessary to contemplate the conditions of funding partnership and distribution rules of funding shares in more detail, taking into account the regional and economic impact of mines, in addition to transport related issues.

Smaller development measures and maintenance in the state transport network are funded from the government budget. However, additional funding is needed, because the budgetary framework does not take into account the emerging special needs of mining industry. The measures are prioritised based on traffic-related needs and effectiveness. Mining companies are responsible for the internal transport routes in the mining area required by their operations and for the loading and unloading areas needed for connecting into the state network.

The funding of the largest development investments is decided upon separately for each investment. Development investments serving the special needs of mining transport are implemented through the joint funding of the government and the mining companies. There are several alternative models. The main funding responsibility may lie with government or the mining company, depending on the situation. It may also be a private road fully funded by the mining company or a private rail or an infrastructure company, with the central interest groups as members. Models based on partnership require long-term co-operation from the government and the mining company. The responsibility for the quality control of building should lie with the government, based on experience.

The government funding share takes care of the functioning of the transport system and supports the regional and economic impacts of mining industry. The commitment of the mining companies to the funding share is based on the local service level required by the mining traffic, the need to build new routes, transport related financial benefits for mining companies and long-term use of the invested in transport solution. Every transport investment is contemplated separately and the decision is based on the created cost-benefit analysis. An extensive report of social impacts is also creaetd of large projects, as well as an environmental impact assessment.

4 Conclusions

It is essential in the immediate and future development of transport infrastructure how the transport and travel needs of extractive industry and other industries develop, what is done in the neighbouring countries of Finland to develop transport routes, and, for example, to use the Arctic Sea connections, and how the transport equipment develops. The needs must be covered in planning, and that requires international co-operation. The transport needs become more specific based on individual mine decisions, and then more detailed planning and implementation needs can be programmed. In the near future, Northern and Eastern Finland mining transport between Europe and far-off countries will be implemented via the Bothnian Bay harbours, irrespective of the sulphur directive. Other transport needs of the industries in the area do not alone significantly impact the mining transport and route selections, but it is expedient to integrate those. In regional zoning, it is good to already take into account the future needs that are visible. The following presents the most significant needs for further actions based on this report.

Next 1–5 years

- Improvement measures (in total about 50 million euros) related to eliminating the bottlenecks of the existing services and transport networks of current mines will be planned and implemented
- Small improvements to transport services will be planned and implemented case by case when new mines are launched
- Further clarification and planning of current transport services will be started for the increasing mining transports that are within sight. They include e.g.
  - Highway 4 from Middle Lapland to Oulu and highway 21
  - the capacity of the railway network in sections Ylivieska–Oulu–Kemi, Kemijärvi–Rovaniemi–Laurila, Vartius–Oulu and possible new freight transfer terminals
  - Kolari and Solki rail links after the mine decisions
  - Growing the capacity of the Bothnian Bay harbours (harbours' own decisions) and deepening of sea routes based on the demand and the sea traffic strategy of Finland and project assessments
- The opportunities to use heavier than normal road transport and the impact on mining transport will be clarified
- A land use reservation will be made in the regional plan for a new railway line to Sodankylä

Medium-term 5–15 years

- The track and rod investments required by the Kolari and Sokli mines will be implemented, provided that the mines will be opened according to plans and the funding of the lines have been agreed upon between the different parties
- After the possible Middle Lapland mine decisions, the further planning and building needs of the Sodankylä–Rovaniemi/Kemijärvi line will be clarified
- Improvement measures required by the existing transport network will be implemented based on mining transport and the need for transport and travel needs of other industries

Future after 15 years

The mining industry of the northern region will be in a lively development phase and will have great economic significance. In transport functions, the current transport network will have been used as basis. Fast changes of the transport network will not be possible. The development of new national transport connections may take years longer than starting mining activities. New ore deposits are constantly being found, and the utilisation of them is dependent on the transport possibilities. In this work it could be stated that mining industry and its transport needs are difficult to predict far into the future. For this reason, there should be continuous co-operation between mines and mining transport both nationally and internationally.

- Future needs will be forecast in collaboration with the neighbouring northern countries
- The development of the Tornio–Haaparanta railway yard and freight terminal, as well as the development of the Narvik route will be investigated together with Swedish authorities
- Increasing the possibilities to use the Vartius route in Finnish mining and Russian transit transport will be studied in co-operation with Russian authorities
- The planning and implementation will take into account the changing traffic needs and possibilities, including the North-East Passage
- Hauling equipment will be developed and the opportunities they offer will be used

The results of this work will be used in the mining working group project "Sustainable extractive industry - Energy, logistics and transport infrastructure" led by the Ministry of Employment and the Economy. Furthermore, the transport and logistics working group of Northern Finland will do follow-up as part of the working group activities. The situation will be re-evaluated in 2015.

Liikennevirasto

Finnish Transport Agency

ISSN-L 1798-8217
ISSN 1798-8225
ISBN 978-952-255-269-3
www.liikennevirasto.fi